

An Infrastructure-Free Localization System for Firefighters

Anthony Rowe
Associate Professor
Electrical and Computer Engineering Department
Carnegie Mellon University



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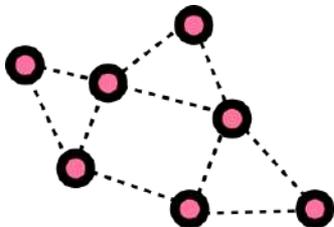
Indoor Localization Platform Goals

Hardware

No prior infrastructure

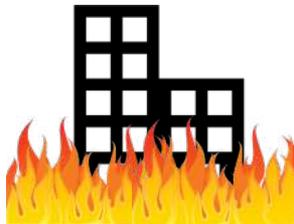


Ad-hoc wireless connectivity



Deployment

Restricted perimeter



No user-effort

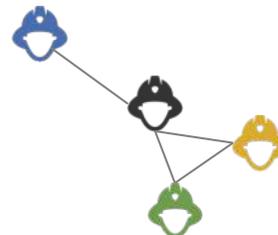


Location algorithm

Absolute location and orientation



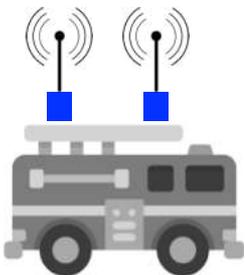
Relative location



Our approach

Pre-install

Beacons on vehicle

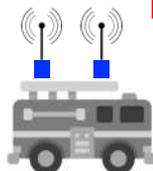


Tags on firefighters



On-site

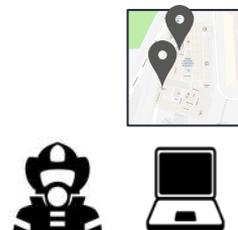
1. Vehicle drives up to building



3. Firefighters go in



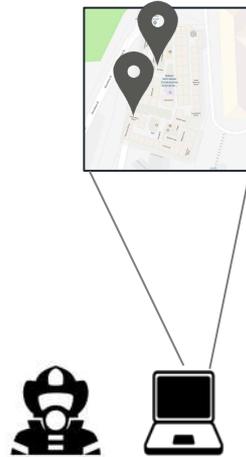
4. Safety chief console



2. Additional beacons (maybe)

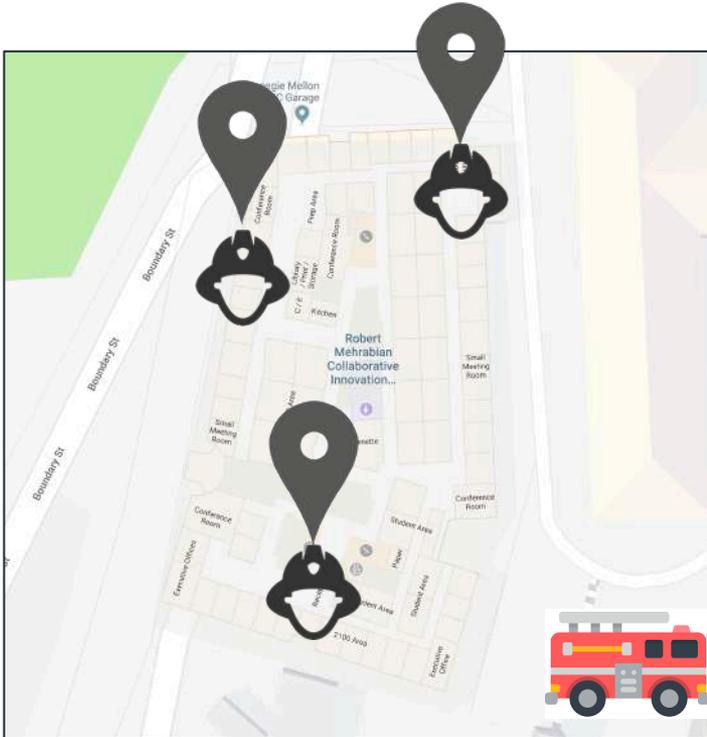


Location Application Scenarios



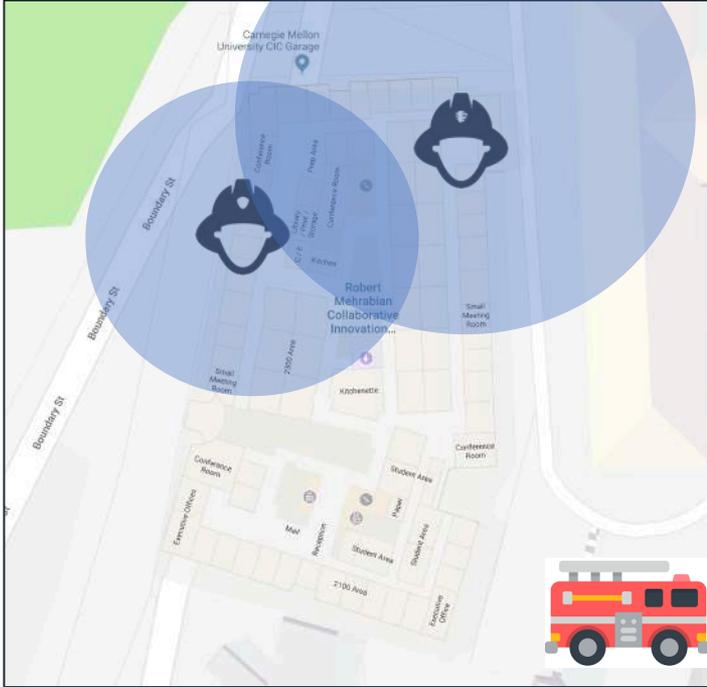
Location inference
on safety chief console

Scenario 1



Absolute location of firefighters on map

Scenario 2



- Absolute locations on map is uncertain
- Relative locations has high confidence

Scenario 3

Unknown location

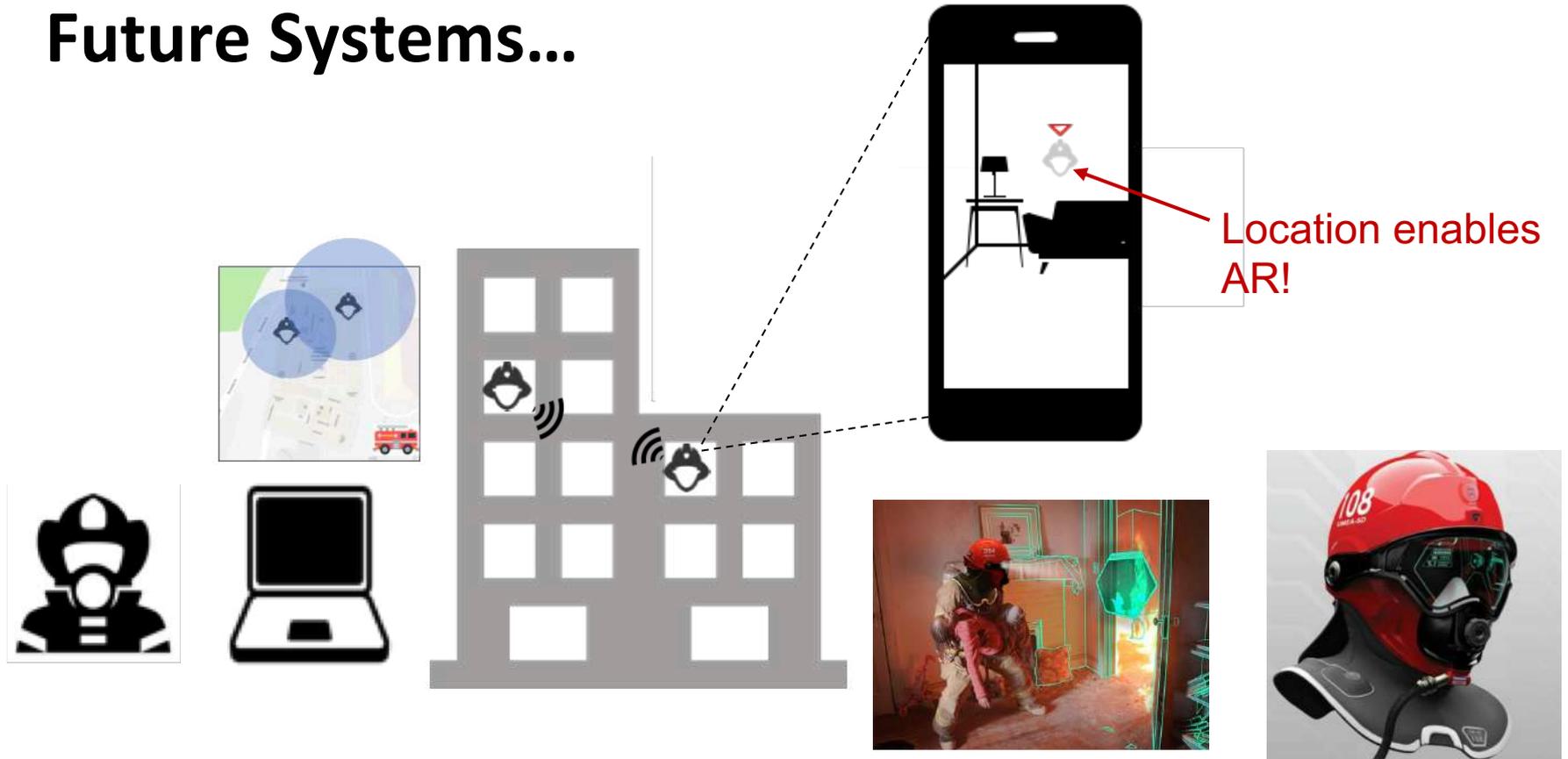


Location identified



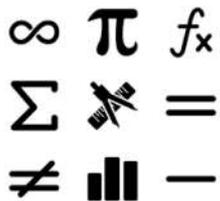
Known locations

Future Systems...

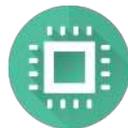


System Components

Location Solver



Sensors



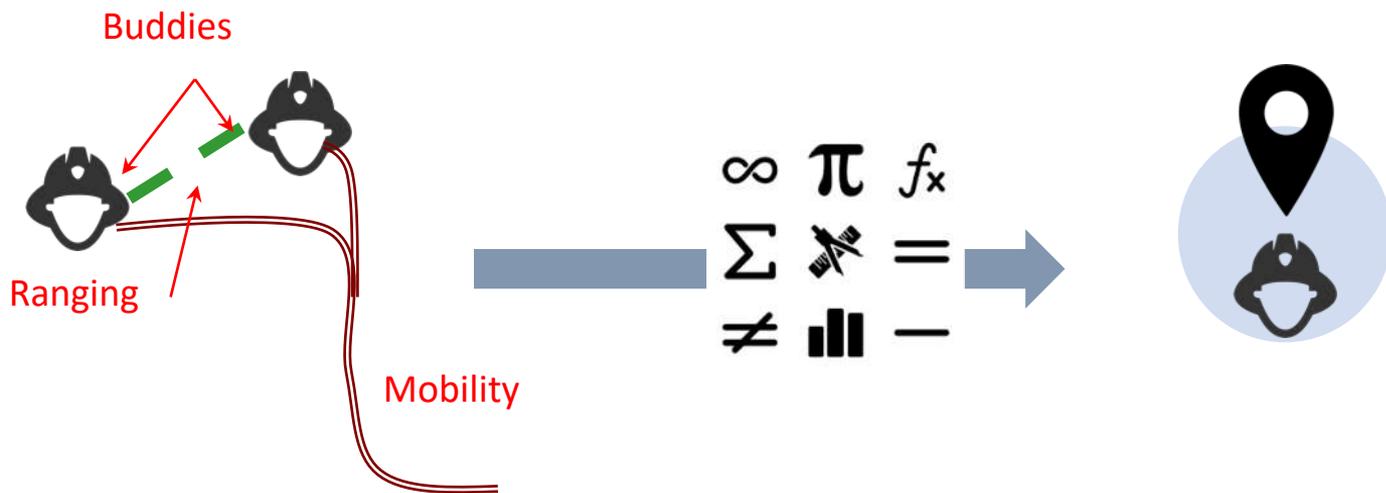
Communication



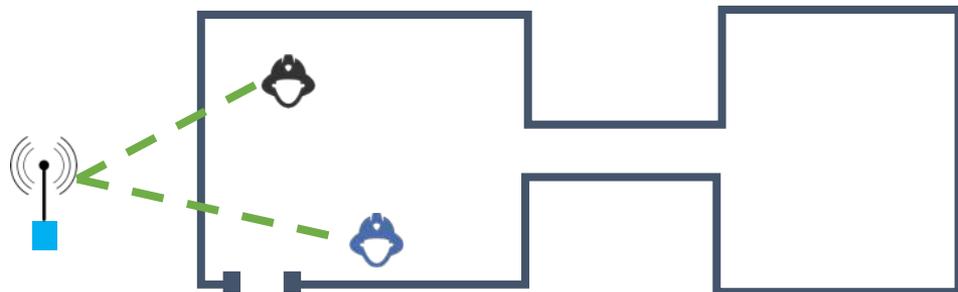
Critical, but not in our project scope....

Location Solving Approach

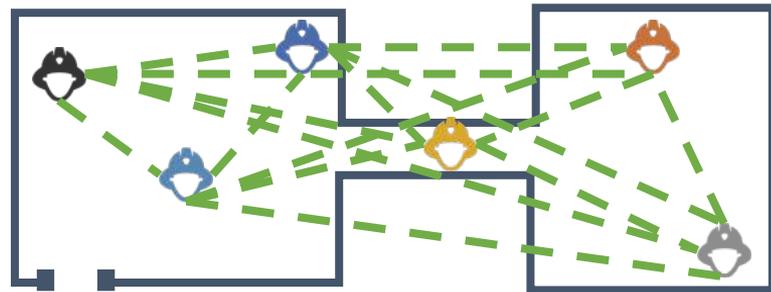
Utilize **ranges** between firefighters and beacons, fused with **mobility** (inertial measurement data) to track location



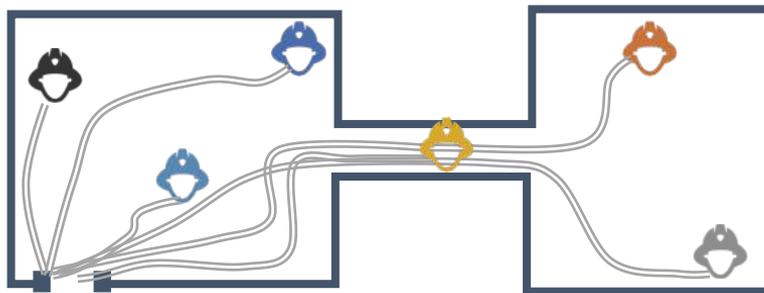
Sensor Inputs



Range to beacons provides absolute positioning

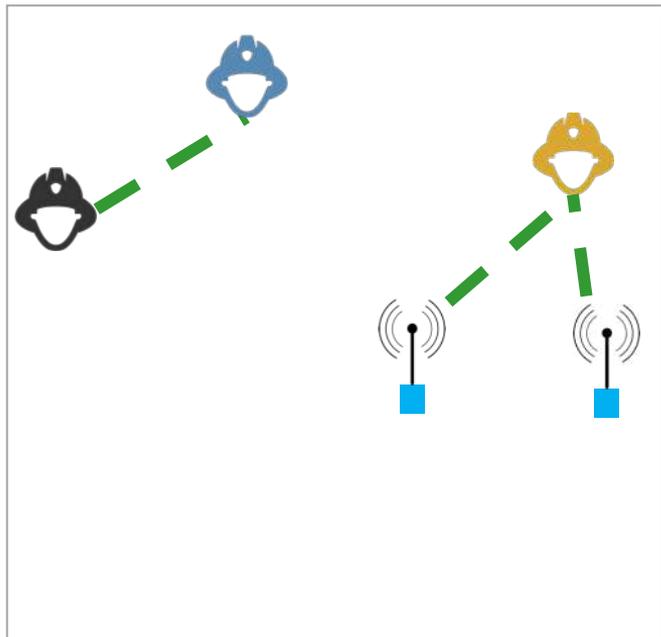


Range between firefighters provides relative positioning

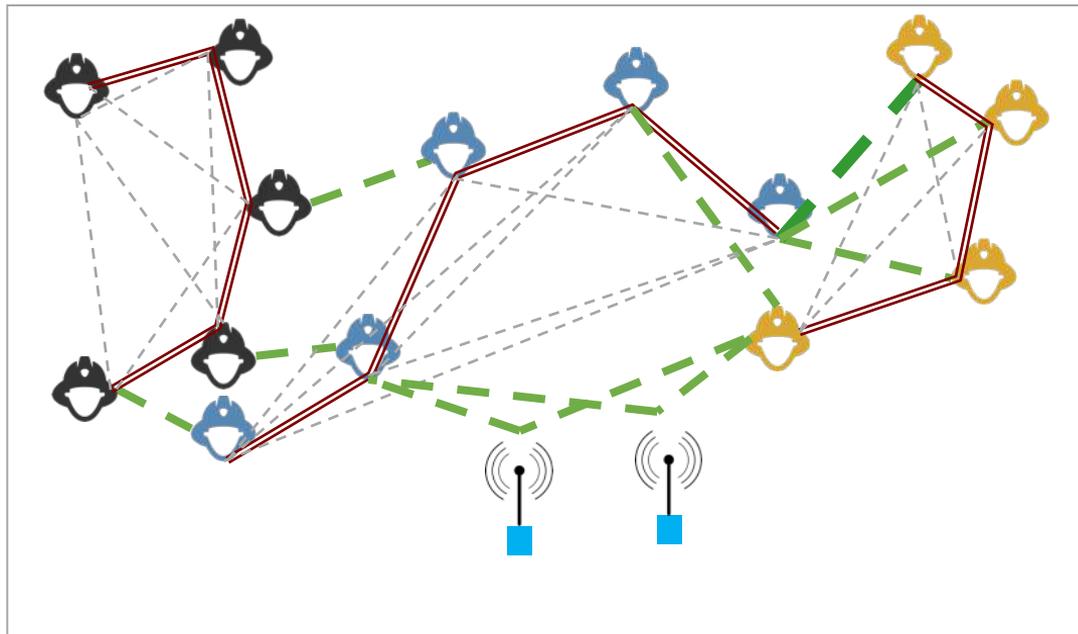


Inertial sensors provide tracking with **Mobility**

Temporal and Spatial Diversity



A Snapshot: Not Solvable



Snapshot Over Time: Solvable!

Heterogenous Sensing

- Device-to-device ranging
- Inertial Measurement Unit
- Visual Tracking
- Sensor driven IMU calibration / training

	IMU Dead Reckoning	Peer-to-Peer Ranging	Beacons (fixed but unknown)	Laser Scanner (single user)
Class 1	X			
Class 2	X	X		
Class 3	X	X	X	
Stage 4	X	X	X	X

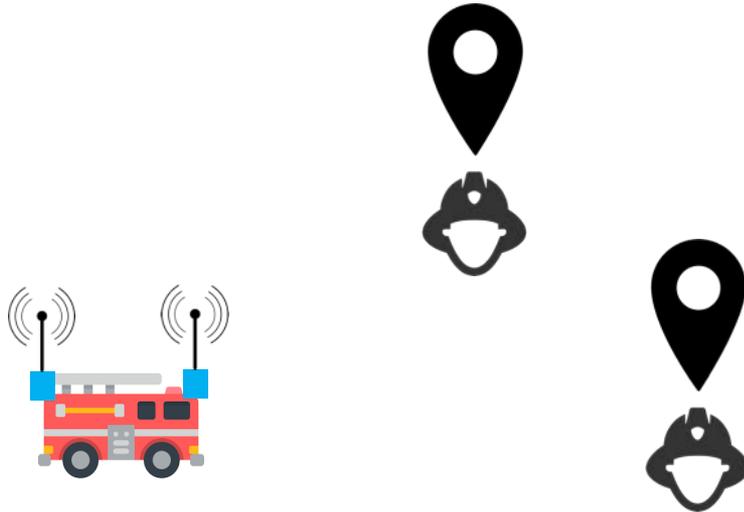
Algorithmic Goal: Approach that spans these classes with a sensitivity analysis in terms of performance

Algorithmic Roadmap

1. Determining position exiting the truck
 - SLAM with poor geometric dilution of position (GDOP)
2. Relative mapping of fixed beacons
 - 3D SLAM on embedded targets
3. Relative mapping of moving targets
 - Network localization
4. Improved IMU tracking
 - Training mobility models

1) Determining position exiting the truck

- SLAM with poor geometric dilution of position (GDOP)



Mobile Phone Localization with UWB and Visual Inertial Odometry

February 1st, 2019

AR Tracking of UWB Tag

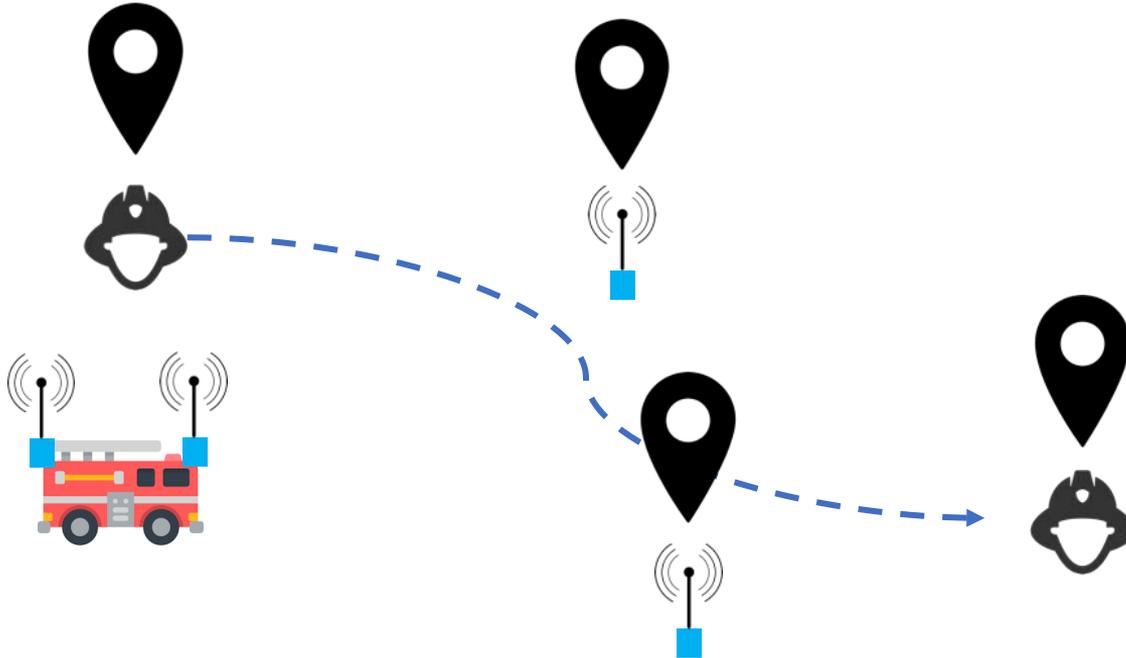
February 1st, 2019

Dropping AR Markers from a Command Console

February 1st, 2019

2) Relative mapping of fixed beacons

- 3D SLAM on embedded targets



Mobile Phone Mapping with UWB and Visual Inertial Odometry

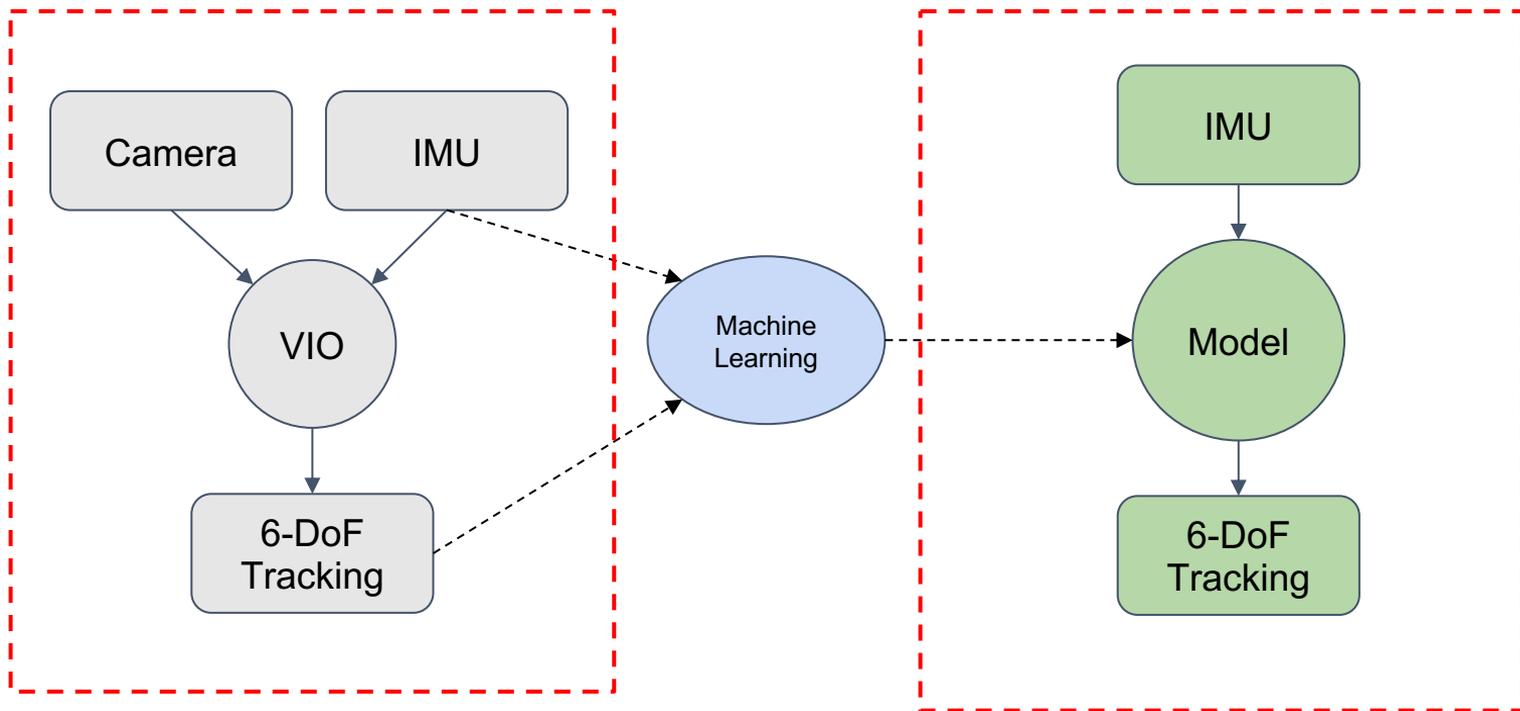
May20th, 2019

3) Relative mapping of moving targets



4) Improved IMU Tracking

Automated learning of mobility model



Current system

Creating Mobility Dataset

Optical Tracker

Our Tracker
w/ Markers

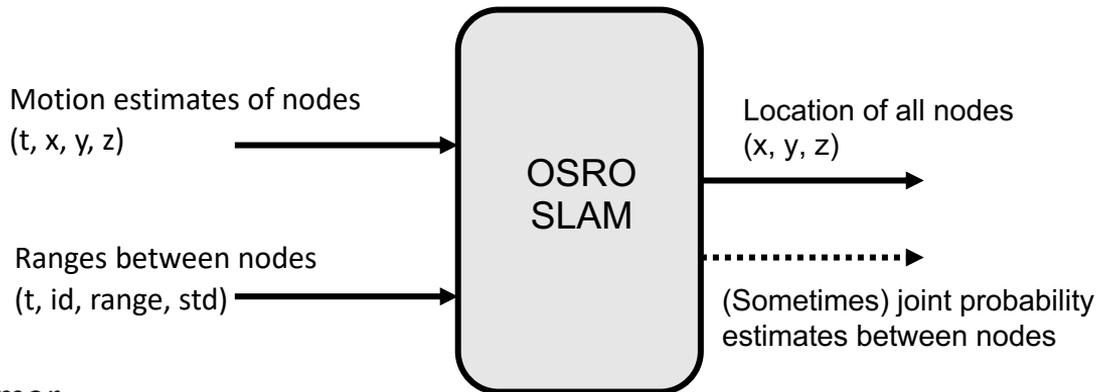


OSRO-SLAM[3D]

Open Source Range Only Simultaneous Localization and Mapping in 3D

Components

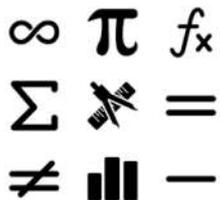
- Matlab Kernel
- Lightweight C Kernel
- Android and iOS Wrapper
- MQTT Network Server



Version 1 release expected late this summer

System Components

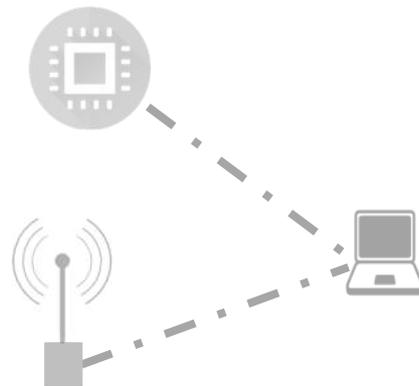
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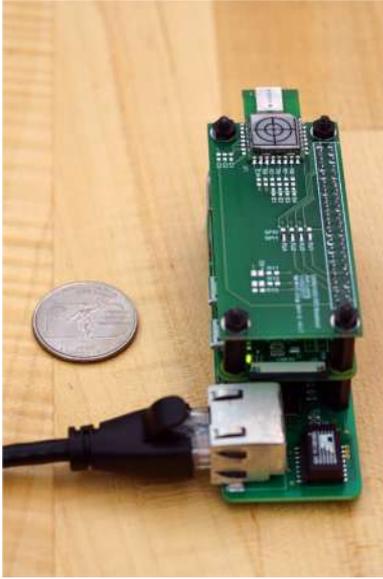


Communication



Critical, but not in our project scope....

Last Year's Prototype (required a mobile phone)



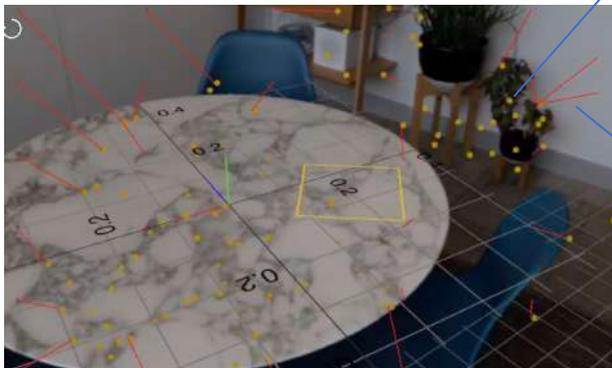
Beacon



Tag

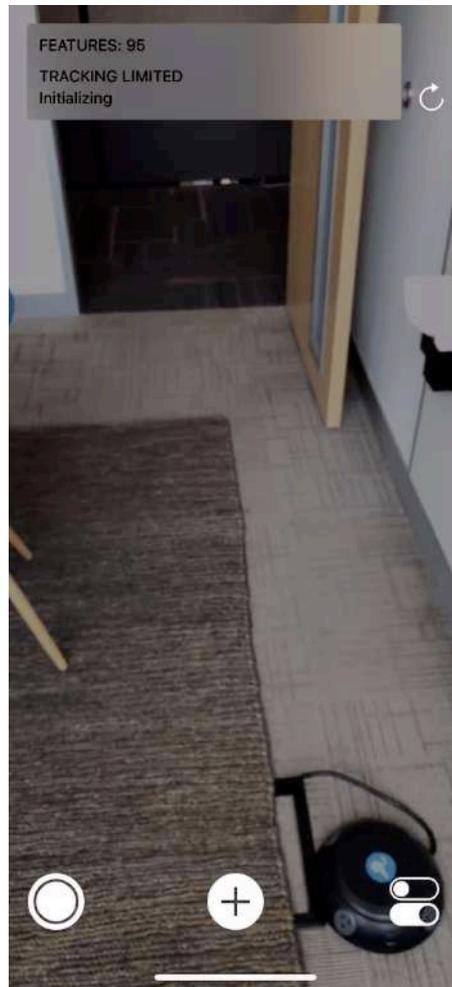
Visual Inertial Odometry

- Optical Feature Tracking
- Inertial Measurement
- Becoming low-cost



Feature
Points

Motion
Vector



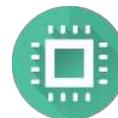
Hardware Components

- GPS
- LoRa (Long Range <1 GHz Communication)
- UWB (Ranging Radio)
- Air Pressure Sensors



(1) Ingress Beacons

- LoRa (Long Range <1 GHz Communication)
- UWB (Ranging Radio)
- Air Pressure Sensors
- Inertial Measurement



(2) Airpack Transponder

System Testbed



LoRa
Gateway

GPS

BME680
(Bosch Air
Pressure
Sensor)

BNO080
(Bosch 9DOF
IMU)

Raspberry Pi

SX1280
(Narrowband
ToF)



ADIS16488
(Tactical IMU)

LoRa
Transceiver

New Integrated Tracking System



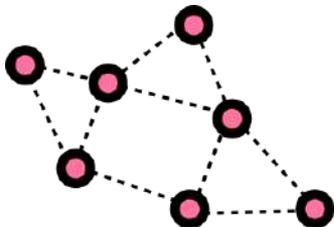
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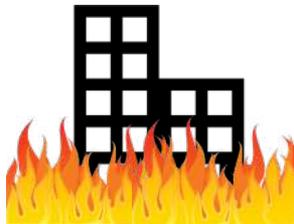


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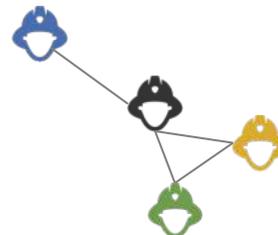


Location algorithm

Absolute location and orientation



Relative location



Demo

1. Three ingress beacons are fixed
2. Two volunteers with tags are mobile and walk around
3. Computer shows locations of the volunteers

New Features compared to last year:

- No phone needed (embedded target)
- Relative AR visualization
- Modular Software and Platform
- Beacon-less relative tracking

Next Steps

- Field Testing
- Robust enclosure added to SCBA
 - Study impact of placement
- Dealing with intermittent sensor data
 - Algorithmic development
- Improve IMU-only system
- Explore new ranging technologies like mmWave

Field Testing

- Capture motion data set
 - Walking, running, crawling, climbing with SCBA in place
 - Multiple body locations
 - Top, middle, bottom of airpack
 - Front strap (good for police as well)
- Capture channel models in different types of smoke
 - Ultra Wide Band RF
 - Laser (multiple varieties)
 - Narrow-band RF



Thank you!

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Session**
1:50 PM